

# The Division of Labour is Limited by the Type of Market: The Case of the Taiwanese Machine Tool Industry

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**Summary.** – This paper seeks to illustrate that the division of labour is limited not only by the size of the market, i.e. aggregate purchasing power, but also by the type of market, i.e. the average income of individual consuming units. Consequently, for technology to advance in the production of certain goods, capital accumulation must occur. The multiplication of markets alone is insufficient. Empirical support for this proposition is provided by an examination of the Taiwanese machine tool industry. Central to the discussion is the treatment of the product as an economic variable.

## I. INTRODUCTION

Adam Smith's theorem, that the division of labour is limited by the extent of the market, is widely recognized as being of fundamental importance to an understanding of the process of economic development. The theorem remains undisputed although economists writing after Smith extended his meaning of the term 'division of labour'. The clarification of the term's meaning within the context of modern industrialism most often cited in the literature is that of Allyn Young:

It is generally agreed that Adam Smith, when he suggested that the division of labour leads to inventions because workmen engaged in specialized routine operations come to see better ways of accomplishing the same results, missed the main point. The important thing, of course, is that with the division of labour a group of complex processes is transformed into a succession of simpler processes, some of which at least lend themselves to the use of machinery.<sup>1</sup>

Furthermore:

In the use of machinery and the adoption of indirect processes there is a further division of labour, the economies of which are again limited by the extent of the market. It would be wasteful to make a hammer to drive a single nail; it would be better to use whatever awkward implement lies conveniently at hand.

In addition to this division of labour associated with the use of specialized machinery, Young goes on to note the derived demands or linkages which prompt a division of labour among industries. To this might be added a division of labour in management functions and, in what follows, by the term 'division of labour' is meant all the forms of modern economic organization and modes of activity in a broad sense. This broad interpretation does not imply the indiscriminate use of capital-intensive techniques at each and every stage of the production process. Rather, modern economic organization connotes mechanization, where necessary, to achieve higher labour productivity by means of machine-placed operations, consistent quality of output and interchangeability of parts.

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The precise meaning of the term 'extent of the market' has received less attention from Smith's epigones although Young attempts to clarify this term also:

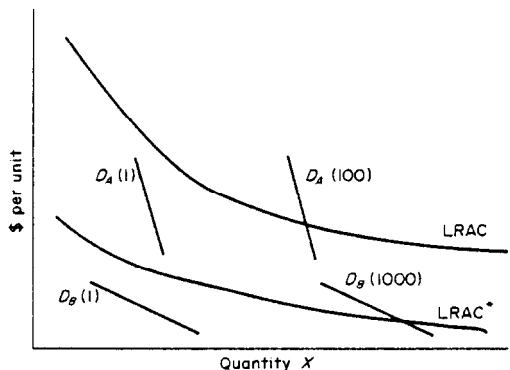
But just what constitutes a large market? Not area or population alone, but buying power, the capacity to absorb a large annual output of goods....

This clarification, however, conceals an important distinction between extent of the market and what may be termed 'type of market'. Smith, as well as others, does appear to have included the narrower concept of 'market type' in the meaning he attached to the term 'extent of the market'. But the distinction is worth making explicit, for two markets of equal purchasing power may contain far different capacities to consume a range of goods, or products with relatively high income elasticities. Assume 100 economic units in market *A* each with an income of \$10,000. Assume 1,000 economic units in market *B* each with an income of \$1,000. Although purchasing power in the two markets is equal, obviously a market of type *A* is a better candidate than a market of type *B* for the absorption of non-essential goods with high unit costs, irrespective of how great increasing returns may be, and hence, relatively high prices.

The machine tool industry in Taiwan, with a history dating no earlier than the end of World War II, has until very recently catered exclusively to a market of type *B*; a large number of low-income machine tool users at home and then abroad as well. This fact has had a crucial impact on the character of the industry. At the outset of production, undoubtedly the small size of the market for Taiwan-made machine tools contributed to low profitability. Low profitability, in turn, discouraged local lending to the industry and an influx of foreign capital and know-how. Undercapitalization and technological backwardness, in turn, reduced profitability still further. Gradual improvements in the techniques of some machine tool firms, however, allowed for, and were aided by, an extension of market size in the form of general advances in productivity at home and exports to Southeast Asia. The later history of the industry spans roughly the last half decade. During this time, a small nucleus of progressive firms has been in a transitional state. There has been a distinct trend toward modernization. Production capacity has increased. By 1974, Taiwan ranked 28th among world producers of machine tools, ahead of countries like South Africa and Mexico.<sup>2</sup> Industry leaders have begun to sell more of a larger output to

high-income markets abroad and to prosperous manufacturers at home, both foreign and local. Nevertheless, low-income customers continue to account for the lion's share of sales. The low value of operating assets and the simple production techniques of the majority of the machine tool industry's customers, which reflect the limited purchasing power of final consumers, have been a major force inhibiting a more elaborate division of labour in the transitional period of the industry's life. It is the purpose of this paper to examine the machine tool industry's history in order to illustrate that the division of labour is limited by the type of market, i.e. the average income of individual consuming units, as well as by its size, i.e. aggregate purchasing power.

In the production of some goods, the application of machinery may of course give rise to better, cheaper products than an older, more labour-intensive process, e.g. more durable, less expensive shoes. Economies of scale may more than offset the rise in capital costs, depending on output levels: i.e. at lower levels of output, older technology may have lower unit costs than newer technology whereas at higher levels of output, the reverse may be true. In terms of Fig. 1, this would represent a switching point and an intersection of the two average cost



$D_A$  = Demand schedule of market *A* (high income market)

$D_B$  = Demand schedule of market *B* (low income market)

(Numbers indicate number ['000] of consuming units)

LRAC = Long-run average cost curve when product *X* conforms strictly with international standards of quality (modern technology employed).

LRAC\* = Long-run average cost curve when the quality of product *X* is below international standards (less modern technology employed).

Figure 1.

curves. For other goods, however, demand may fail altogether beyond a certain level of costs. That is, whatever the cost and price reductions achieved by a more elaborate division of labour in industries subject to increasing returns, such cheapening may still be insufficient to attract demand by low-income consuming units. This obtains even if market size is increased by the multiplication of the number of such units. For such goods, the achievement in poor countries of still greater cost and price reductions may paradoxically necessitate a return to an earlier Western technology, embodying a less refined division of labour, and the production of a final product familiar in appearance and performance to Western consumers of half a century ago.

In Fig. 1, the Marshallian long-run average cost curve (LRAC) may be hypothesized to belong to a local firm in an underdeveloped country facing a market of type *B* for product *X*. It is assumed that costs per unit of output have been minimized given relative factor prices. That is, it is assumed that whatever substitutions among factors of production which are profitable to effect have already been effected.<sup>3</sup> But whatever the capital-labour ratio chosen, the character and quality of product *X* conform strictly with an internationally accepted standard. This is not to argue that the quality of a good remains invariant all along its LRAC. Quality may rise as production techniques are adjusted for different quantities of output. But it is postulated that quality varies only within a limited range. Large quantum improvements in quality raise absolute costs and involve an upward shift in the average cost schedule.

If a firm faces a market of type *B* and has at its disposal the resources to produce in a manner prescribed by LRAC, such a supply and demand relationship may be descriptive of an underdeveloped country where there is no shortage of funds and know-how for investment but rather an absence of profitable domestic investment outlets. Entrepreneurs just beginning production in many underdeveloped countries, of course, generally do not have such a proliferation of resources at their disposal. Both costs and prices may be lowered, however, to reach an equilibrium by two procedures. Both involve producing a good not strictly comparable to product *X* either in quality or complexity but designed to serve its same general purpose. Firms may in theory produce a simpler model or a miniaturized version of product *X* (e.g. a straight stitch rather than a zigzag sewing machine; a low rather than high

hp tiller). As product *X* is qualitatively transformed, costs and prices may be hypothesized to fall until supply and demand are equilibrated. Not all goods, however, can be miniaturized or simplified. In such cases, a second alternative presents itself for lowering costs to produce at a price which a market of type *B* finds attractive. Such a sleight-of-hand may be accomplished by producing a poorer quality good (represented by LRAC\*) by means of less modern, complicated and costly techniques than a good of standard quality would necessitate. Such was the path followed by the Taiwanese machine tool industry.

A less elaborate division of labour in the production of a low quality machine tool for profit appears to have been economically rational, in a static efficiency sense, given prevailing cost and demand conditions. It allowed the Taiwanese machine tool industry to come alive precociously, at a time, and in a setting, of relative economic backwardness. By contrast, the manufacture of many socially desirable products with cost and demand schedules like those depicted by LRAC\* and  $D_B$  in Fig. 1, never sees the light of day in other underdeveloped countries. A less elaborate division of labour in the production of a lower quality machine tool also suited the factor endowments prevailing in Taiwan at the time. It allowed machine tool users to economize on capital expenditures and to produce their final products with equipment far superior to the hand tools with which their ancestors had to make do. It also protected machine tool builders from ruinous competition from advanced countries (except possibly Japan). For the quality and price of Taiwan-made machine tools found acceptance in a market altogether impenetrable by foreign firms. Nevertheless, at present, the Taiwanese machine tool industry is caught between two markets: one, low income, and traditionally the mainstay of the industry; the other, high income, holding out the challenge of technological advance and the promise of faster growth. How industry leaders arrived at this crossroads, and how the industry's past acts as a determinant of its future, are the subject of the discussion which follows. In the discussion, the question of when it pays to start producing higher quality goods is raised. The difficulties involved in making the transition are aired. The product as an economic variable (in Chamberlin's terminology), in relation to price and quantity, is central to the discussion.<sup>4</sup>

Information on machine tool production is largely descriptive and is based on visits to 40

firms in Taiwan; interviews with businessmen, foreign and local technical consultants, and government officials; government documents and published material where available; and discussions with distributors and users of Taiwan-made products in Hong Kong and some Southeast Asian countries.<sup>5</sup> The history of the industry is divided into two parts. The first traces the industry's growth from its infancy and is organized around Adam Smith's theorem that the division of labour is limited by the size of the market. The second part illustrates that the division of labour is also limited by the *type* of market.

## II. THE TAIWAN MACHINE TOOL INDUSTRY: THE DIVISION OF LABOUR IS LIMITED BY THE SIZE OF THE MARKET

After a short-lived surge in activity induced by post-World War II shortages and urgent reconstruction needs, many branches of Taiwan's infant machinery industry entered a period retrospectively described as the Dark Ages.<sup>6</sup> Inadequate demand due to low productivity throughout the economy became a major stumbling block of machinery manufacturers, machine tool builders included.

The earliest machine tool shops evolved to provide repair and reconditioning services to small local firms. Later such activity was superseded by the manufacture of complete units of lathes, drill presses and punching machines. Manufacturing, however, was on a made-to-order basis. Production was organized by individual job rather than by a batch system. The small and unsteady flow of orders for machine tools precluded the possibility of long runs or even job lot production. Custom-made activity was not conducive to standardization or interchangeability of parts. There was little stocking of standard models or selling from catalogue descriptions. The result was a final product of crude quality at relatively high cost.<sup>7</sup>

The demand facing the Taiwan machine tool industry was fragmented further by the influx of a fairly large number of small, would-be machine tool builders during the temporary surge in activity after World War II. Competition was severe. Firms left the industry as rapidly as they entered it. By 1961, however, there were only 38 machine tool companies in the country (30 had fewer than 10 workers each). Of these 38 firms, only 14 had been in operation for more than five years.<sup>8</sup> Cut-throat competition on the supply side, coupled with

the fact that demand came largely from small-scale, financially weak machinery works and repair shops, established early on a fundamental characteristic of machine tool establishments: their price rather than quality consciousness.

A picture of the activities of machine tool users can be pieced together from the information provided by machine tool builders themselves and from visits to what appear to be representative firms.

The earliest users of Taiwan-made machine tools were small, family-operated concerns in the metal and machinery sectors. They were engaged primarily in processing and repairing and secondarily in manufacturing. In 1961, such concerns numbered some two thousand.<sup>9</sup> Machine tools would be indispensable to such concerns for the repair of products like bicycles and taxis; rice milling equipment and agricultural implements; as well as for the manufacture of spare parts for these products. The local manufacture of such parts cheapened them and reduced a dependence on imports.

The purchases of machine tools by small machine-making and metal-working enterprises were also important. Such enterprises would require machine tools for maintenance purposes as well as for the production of hand tools and cutlery, nails and chains, bicycles and miscellaneous machinery. An unincorporated concern with 45 workers, engaged in the production of semi-automatic shoe-making machinery, appears typical. It purchased all its machine tools locally.

Of recent importance to the machine tool industry is the demand of small satellite shops which have evolved in conjunction with prime producers of sewing machines, agricultural machinery and transport equipment.

Of even more recent importance is the demand for the best Taiwan-made machine tools by the prime producers of machinery themselves. Demand, however, is restricted to simple, general purpose models, if not for direct use on the assembly line, then for maintenance and repair.

From this sketch of the activities of machine tool users, a clearer picture emerges of the linkages connecting the machine tool industry and the rest of the economy. The machine tool industry ultimately benefited from a land reform in the 1950s and from what became the major economic pursuit in Taiwan starting in the 1960s: the export of labour-intensive manufactures. With a phenomenal rise in such exports, capital accumulation and *per capita* income increased throughout the economy. So too, indirectly, did the demand for machine

tools. A more direct linkage was the demand for machine tools by the producers of leading export items such as sewing machines and bicycles. There was even a trickling down from the manufacturers of parts for electrical appliances and telecommunications, whose capital stock included such machine tools as drill presses, punch presses and centerless grinders.<sup>10</sup> The textile industry bought some of its capital equipment locally and textile machinery manufacturers in turn demanded machine tools. Indeed, several leading machine tool builders today originated as manufacturers of textile machinery (the origins of leading American machine tool builders are similar). Many continue to produce a diversified product mix.

One commonly hears the argument that international firms engaged in the export of labour-intensive manufactures typically fail to extend capitalist production to the rest of the local economy in which they operate. This proposition appears untenable at least in the case of machine tool production in Taiwan. For linkages, through the demand nexus, were forged between foreign-owned firms in Taiwan and Taiwanese machine tool builders. Nevertheless, what was *not* achieved was an intimate technical relationship between the two. Herein lies a crucial difference between the Taiwan machine tool industry and the machine tool industries which evolved over a century ago in what are now industrialized countries. We are told, for example, that the American machine tool industry benefited enormously from ongoing interactions with its customers: first the armaments industry, then sewing machines, bicycles, automobiles, and aerospace.<sup>11</sup> As these industries advanced and became needful of ever more sophisticated and specialized capital equipment, they coached and compelled machine tool builders to advance along with them. This close, complementary, technical contact was absent in the history of the Taiwanese machine tool industry. Only after the most enterprising machine tool builders had succeeded by trial and error in producing a standard product, did sales to large-scale manufacturers of sewing machines, bicycles, and automobiles materialize. The high precision and specialized machine tools used by such manufacturers were, and are still are, imported from abroad.<sup>12</sup> While the American machine tool industry evolved to serve the increasingly exacting needs of armaments manufacturers, Taiwan's leading arsenal, which contributed to the country's enormous military efforts, produced its own machine tools with foreign assistance. Security precautions prevented an

exchange of technology with the private sector.<sup>13</sup> The government-owned shipyards and large machinery works were also self-contained (these and other government-owned corporations accounted for as much as 56% of industrial net product in 1952).<sup>14</sup> The technical know-how of Taiwanese machine tool builders was acquired painfully and pragmatically, without the assistance of the small minority of its users which was technologically advanced.

This clearly had a retarding effect on the industry. Some machine tool builders had gained a basic knowledge of mechanics while employed in Japan or in Japanese-occupied Manchuria during the 1930s. A practical knowledge of machine tools, however, was acquired even less formally. The most common channel for 'technological transfer' before the late 1960s appears to have been the knocking-down and copying of post-World War I models.<sup>15</sup> Thus, while the production of machine tools on a made-to-order basis condemned the industry to short runs and contributed to non-standardized technical practices, the insufficient know-how of most tool builders determined that the situation could not have been otherwise. And very briefly, the energies which the industry expended in improving techniques left little time for attention to sound management practices. A government report despairs of the absence of 'cost-consciousness' on the part of machine tool manufacturers, more preoccupied with the mechanics than the business side of their trade.<sup>16</sup> Production costs were said to be underestimated in ignorance. To break even, corners were cut and quality was sacrificed. It was also said that buyers drove such hard bargains that suppliers' impressions that price alone mattered were reinforced.<sup>17</sup>

A striking feature of the structure of machine tool production in Taiwan was, and continues to be, a low degree of specialization and a high degree of vertical integration. The all-purpose nature of operations in the smaller firms has been very pronounced. Larger firms have engaged in even more activities which are ancillary to the production of machine tools. In industrialized countries, such activities would typically be sub-contracted.<sup>18</sup>

The structure of machine tool production in Taiwan is partly a function of market size. The energies of owner-operators do not appear to have been exhausted in the specialization of machine tools for which demand has been limited. Long hours of slack, valued at almost zero opportunity cost, have been filled by the production of every conceivable part for the

final product. From Adam Smith's theorem and from George Stigler's development of the theorem, we expect that as the size of the market expands, it becomes more profitable to concentrate resources in a single line.<sup>19</sup> Costs are minimized by doing business with specialized components manufacturers which evolve to meet the needs of technically convergent families of enterprises.<sup>20</sup> Not yet in evidence even in the larger machine tool factories in Taiwan, however, is a movement toward vertical disintegration and the patronage of support industries. This has been both cause and effect of the dearth of many types of support industries such as foundries, forges, heat treatment, electroplating, and tools and dies. Early on, when production was getting under way, machine tool builders were faced with the choice of either importing their inputs or making them where possible. The small size of the market, however, as well as a critical shortage of foreign exchange, made a reliance on dispensable imports unthinkable. The research and paper work involved in correctly specifying an order in a foreign language for components of diverse grades and dimensions is costlier the smaller the order. By becoming self-sufficient, the frequency of transactions was minimized.

Self-sufficiency in machine tool production (and in the manufacture of machinery in general) has been ascribed by local observers to Taiwan's sales and commodity tax structure, which does in fact penalize non-integrated firms, and to the 'Chinese character'. It is argued that Chinese culture values independence in business highly. 'Integration' carries a favourable connotation. Nevertheless, it would be incorrect to reduce integration to a purely cultural phenomenon, for there are indications that it is endemic in many countries new to industrialization.<sup>21</sup> It is even pronounced in the Peoples' Republic of China (PRC). A comparison of the structure of machine tool production in the ROC (Taiwan) and the PRC is of interest not simply because of the obvious contrasts and connections between the two countries. A comparison is also of interest because Chinese machine tools, at present, appear to pose as the main source of competition to Taiwanese exports.

In an exhaustive study of the Chinese machinery sector in the 1950s and early 1960s, Chu-Yuan Cheng ascribes the phenomenon of vertical integration to the goal of plant-wide self-sufficiency promulgated in China's First Five-Year Plan (a manifestation of the 'Chinese character?'); to a legacy of 'omnipotent plants'

bequeathed by the Soviet Union where self-sufficiency is also pronounced; and to the Communist market structure and planning apparatus.<sup>22</sup> According to Cheng, unforeseen breakdowns in distribution and serious supply bottlenecks made it desirable in the 1950s for a single plant to internalize the production of as many items as possible. Cheng, however, also stresses a factor not derivative of China's market structure – the lack of uniform industrial standards in products and components throughout the capital goods department:

The lack of standardization and the resulting uncertainties in the supply of parts and services from other plants became the root of the self-sufficiency pursued by many large plants.

We have argued that self-sufficiency in machine tool production in Taiwan is essentially a phenomenon of market size; and the lower the level of industrialization economy-wide, the smaller the market. Demand constraints are clearly not operative in the Chinese machine tool industry. A common cause of self-sufficiency in both countries, however, is an absence of uniform standards in metalworking. Two types of standardization may be distinguished. One refers to the interchangeability and uniformity of tolerances, threads and gauges of such basic components as nuts and bolts and bearings. In the ROC, the absence of this type of uniformity reflects pragmatic industrialization left to the devices of individual producers. As in the case of market size, the lower the level of industrialization, the less developed the uniformity of standards. In the PRC, during the period covered by Cheng's study, the absence of this type of uniformity was endemic in the numerous small-scale machine shops that were built in 1957 as a result of the government's policy of decentralization. A second type of standardization refers to the interchangeability of parts and products *between* large factories which have already achieved internally the first type of elementary standardization. In the ROC, basic parts and products do not appear to be standardized among firms of different nationalities within certain industries. The sewing machine industry is perhaps the best example. Nor may such standardization be expected to develop, given the technological independence and secrecy of competitive firms. In the PRC, a lack of uniformity of this second type in the 1950s reflected foreign domination in the pre-1949 era. According to Cheng, plants constructed in occupied Manchuria followed Japanese standards. In Shanghai and other coastal cities, Western standards prevailed.

For our purposes, of immediate interest are the hindrances to industrialization posed by verticalization, principally in the larger firms, and these are described masterfully by Cheng. In China,

since each plant had to do jobs ranging from basic production processes such as iron casting, crushing, welding, heat treatment, electro-plating, machine-processing, and assembling to such auxiliary production processes as overhauls...it confronted complicated problems of craftsmanship and complex management.

The spreading thin and dispersion of skills over a wide range of jobs appears to have been as prevalent in the history of machine tool building in the ROC as in the PRC. As mentioned below, problems of managerial coordination have also begun to emerge although the largest machine tool plants in Taiwan are roughly one-tenth the size of the largest machine tool works in China.

Cheng goes on to note another drawback to verticalization:

...because each plant had to produce all its parts and components, it had to maintain a great variety of equipment. The rate of utilization was therefore extremely low.

Cheng singles out the auxiliary operation of casting as an example. In Taiwan as well, the low utilization rate in the cast iron foundries attached to machinery works has come in for particular criticism; and casting products constitute a very high proportion of the tonnage of machine tools, on average between 50% and 60%.<sup>23</sup>

Verticalization is not without its merits. In Taiwan, the internalization of production of some ancillary inputs has had the advantage of selectivity and flexibility. As discussed later, it has allowed machine tool builders to adjust and to determine independently the quality of some of their inputs. In China, verticalization ensured uninterrupted production in individual plants. Nevertheless, Cheng argues that the demerits of verticalization far outweigh the merits on an industry-wide basis. He concludes with an observation on verticalization that harbingers the future problems machine tool production in Taiwan is likely to encounter as an attempt is made to upgrade and diversify output:

The defects of vertical integration [in China] became more conspicuous when the industry gradually moved from the production of simple machines to complicated machines. As sophisticated machinery usually involves thousands of component parts, which cannot be supplied by any single plant, specialization and close coordination become imperative for its production. After 1963, drastic measures were taken to reform the system.

To date, drastic measures have not been taken in Taiwan. It is noteworthy that in England over one hundred years had to elapse after the start of the Industrial Revolution before uniform, industry-wide standards began to take hold. And generally standardized precision work *within* individual plants long preceded the adoption of common industry-wide norms.<sup>24</sup> In Taiwan, such standardized precision work within even the best machine tool shops still appears to be lacking. Sub-contracting has become institutionalized in a few branches of the machinery sector where foreign capital plays an important role, namely sewing machines, agricultural equipment and automobiles. Apart from the advantages which sub-contracting confers – advantages which are evidenced by the willingness of some prime producers to surround themselves with a constellation of satellites – foreign firms and joint ventures in the above-named branches have been forced to sub-contract by law.<sup>25</sup> Leading firms in each branch have been instrumental in forcing sub-contractors to adopt rudimentary standards within their own shops. But sub-contractors must still differentiate the parts they manufacture to meet the varying specifications of different prime producers.<sup>26</sup> Vertical integration and all-purpose production, however, continue to be the norm in most local prime machinery manufacturing companies. Leading machine tool builders report with pride that roughly 90% of their parts are produced internally.

By the early 1960s, machine tools were still a depressed industry in Taiwan. Feeble demand continued to inhibit specialization and efficiency while shortages of capital, technical expertise and managerial finesse persisted. The late 1960s, however, represented a major turning point in the industry's history: or at least a major turning point for some firms within the industry. For as in other semi-industrialized countries with sizeable machine tool sectors such as Brazil and Argentina, and even the PRC, machine tool production in Taiwan has a dual character.<sup>27</sup> Existing side by side with a nucleus of progressive firms is a majority of shops with negligible sales volumes and primitive techniques. In 1966, 80% of all machine tool firms in Taiwan had fewer than 20 workers.<sup>28</sup> While the situation had changed somewhat by 1973, less than half of all machine tool builders employed more than 20 workers and only a handful employed more than 100.<sup>29</sup>

It was among the larger firms that an important shake-out occurred in the late 1960s.

Many larger firms shut down or shifted to other industries because of low profitability, to the great relief of survivors. A few new firms entered, and with initial capital outlays in excess of what most old-timers began with. On net, however, the number of leading producers fell. By the early 1970s, only some 40 firms were judged to be 'of rather high standard'.<sup>30</sup> This depletion of numbers reduced the fragmentation of the market and shifted demand upward for the remaining firms. The industry began to exhibit a degree of concentration. It has been estimated that eight firms accounted for almost 45% of all lathes built in 1972 (lathes are the major type of machine tool produced in Taiwan).<sup>31</sup> This estimate appears to be far too low. In any event, the eight firms dominated the export trade and accounted for a far larger share of the value of total production since their lathes were comparatively high priced. Two firms with roughly 400–600 workers each accounted for almost three-quarters of the number of lathes produced by all eight firms combined.

It was shortly after this concentration that

the fortunes of the industry changed rather abruptly for the better. On the one hand, such gains represented the culmination of 20 years of cumulative technological advance of almost imperceptible increments. On the other hand, the accelerated pace of improvements, discernible in the larger firms, reflected a general revolution which was spearheaded by the export of labour-intensive manufactures. The accumulation of capital by exporters of labour-intensive manufactures created a slight easing of conditions in money markets. The supply of long-term capital to the more promising machinery makers became more accessible.<sup>32</sup> As one study revealed, a sizeable fraction of the machine tools used to make other machine tools by 1972–73 were of recent vintage (and more than half of such equipment was made in Taiwan).<sup>33</sup> The economy-wide prosperity which accompanied the strides in productivity set in motion by export activity raised demand for a wide assortment of metal working equipment (see Table 1 for output figures). As the size of the market expanded, it became profitable to introduce new machinery.

Table 1. *Production of machine tools (private sector)*<sup>1</sup>  
(Number of sets)

Year <sup>2</sup>	Lathes	Drilling machines	Punch machines	Other machine tools
1961	553	940	650	176
1962	1073	1145	723	202
1963	1702	1879	848	355
1964	2586	2619	1102	496
1965	3253	3394	1453	635
1966	3904	4849	1918	1151
1967	4420	5325	2036	1685
1968	5375	6038	2861	3152
1969	5539	7438	3015	3625
1970	5757	9298	3068	5713
1971	4800	16047	4239	8765
1972	6246	24003	9404	13892
1973	8329	25358	8759	16163
1974*	6940 (7707)	11192 (16112)	4520 (2423)	3497
1975*	6868 (7933)	9286 (26632)	2755 (2508)	2439

Source: *Industry of Free China* (February 1976), Table 13.

Figures for 1961–63 from *Taiwan Industrial Production Statistics Monthly* (MOEA), (October 1974), Table 7.

Notes: <sup>1</sup> Production figures are subject to wide margins of error due to the sampling and inference procedures involved.

<sup>2</sup> Figures for earlier years are unavailable.

\*Bracketed figures for these years are estimates of the Metal Industries Development Centre based on a survey of the machine tool industry in December 1975.



There is little doubt that the international market played a direct and crucial role in the machine tool industry's upturn. Home demand continued to be the industry's main source of support. But very quickly, the domestic market was saturated for the universal machine tools which local firms produced. Of great importance was the fact that deficiencies in home demand were made up for by exports to Hong Kong and Southeast Asia (the Philippines, Thailand, Indonesia and Vietnam). By the 1970s, between 25 and 40% of Taiwan's machine tool output was exported.<sup>34</sup>

The faster pace of improvements in the industry also coincided with the Vietnam war and the ensuing synchronized boom in the economies of the advanced capitalist countries. The effect on the industry of world-wide shortages of capital equipment was electrifying. Buyers in search of standard lathes, punch presses and milling machines unavailable else-

where appeared at the salesrooms (or agents) of leading Taiwanese companies. Fast delivery was an important selling point. So, too, was the price of Taiwan-made machine tools, which appeared all the more attractive as world prices soared. Exports principally to Japan, the US and Australia rose from nil to roughly 30% of all machine tool exports (see Table 2). These exports raised the expectations of leading producers. Such sales held out the possibility of gearing production to larger, wealthier markets. Not that the exports to the US, Japan and Australia were high-precision, specialized lines. They were general-purpose machine tools which met the needs of relatively small-scale machine shops or the maintenance departments of larger factories.<sup>35</sup> Nevertheless, by comparison with customers in underdeveloped Asia, customers in the advanced countries demanded a more reliable product, with interchangeable parts which could be ordered by catalogue when

Table 2. *Taiwan machine tool exports: 1966, 1970, 1973 – value NT\$1,000 and distribution by country*

Importing countries	Types of machine tools					
	All Machine Tools		Lathes		Drill Presses	
	Value	%	Value	%	Value	%
1. Japan, Australia, New Zealand						
1966	234	.5	—	—	4	—
1970	3100	3.7	549	1	1706	16
1973	32858	10.5	16208	14	9573	16
2. Other developed countries						
1966	—	—	—	—	—	—
1970	2528	3	1600	3	109	1
1973	55321	17.7	24959	21	19825	34
3. E. and S.E. Asian underdeveloped countries						
1966	52922	99.5	21460	100	9876	99.9
1970	76996	91.3	46969	95	7511	72
1973	216620	69.2	73640	63	25397	45
4. Other underdeveloped countries						
1966	—	—	—	—	—	—
1970	1633	1.9	483	1	1040	10
1973	8069	2.6	1320	2	3121	5
5. All countries						
1966	53156		21460		9880	
1970	84257	100	49600	100	10367	100
1973	312868		116127		57916	

Source: Statistical Department, Inspectorate General of Customs, *The Trade of China*.

needed. To orient production toward this market, and eventually to displace Taiwan's imports of sophisticated machine tools with domestic substitutes, required the upgrading of quality.

### III. THE TAIWAN MACHINE TOOL INDUSTRY: THE DIVISION OF LABOUR IS LIMITED BY THE TYPE OF MARKET

If the size of the market limited the division of labour, the demand preferences of the majority of machine tool users did so as well. Quality fell short of international standards as a consequence. To upgrade quality, the introduction of a relatively costly complex of production techniques was necessary. Price increases would have to follow to protect profit margins. Given the demand preferences of the majority of the machine tool industry's proven customers, however, the risks involved appear to have been considerable.

The high price elasticity of demand of local and Southeast Asian customers was not rigidly fixed. It could be expected to change with improvements in the material conditions of such customers and inter-relatedly, with the growth in income of final consumers; for rising incomes of final consumers generally alter product requirements and hence, those of intermediate goods. Given the immediate income profiles of both capital goods users and ultimate consumers, however, cheap Taiwan-made machine tools were popular. Specifically, they fitted in with the business objectives of price-conscious customers. One such objective appears to have been a quick realization of profits. This is indicated by a report on the Philippine market for machine tool imports:

Competition from the ROC [Taiwan], whose products are gradually gaining acceptance in the market, should increase. Chinese [Taiwanese] sales of metal finishing equipment to the Philippines consist mainly of small machine tools and light metal-working equipment. Knowledgeable sources claim that at least 60% of the small machine shops utilize Chinese equipment. Although the quality is considered poor – the normal life span is two years – buyers with limited budgets buy Chinese equipment to realize the fastest return for minimum investment.<sup>36</sup>

Not only were Taiwan-made machine tools economically suitable insofar as they minimized investment outlays in the short run; by comparison with higher quality machine tools, of roughly similar design and labour requirements in use, they also appeared to minimize the total costs of Asian buyers, without jeopardizing the

quality of their output. For Taiwan-made machine tools were suitable to the needs of Asian buyers in a technical sense. Although such capital goods were of inferior quality by international standards, they were good enough for the fabrication of the final products which Asian buyers themselves manufactured as well as for purposes of maintenance. This is suggested by a report on the Thai market for machine tools. It was written in the 1960s and refers specifically to Japanese-made equipment. Nevertheless, the report is relevant because it appears that the simple Japanese machine tools competitive in Southeast Asia not long ago were comparable to the Taiwan-made models in use in Southeast Asia at present:

Both the work capacity and the quality of materials *produced* by Japanese machines were considered [in Thailand] equal to those of other countries while the quality of the Japanese metal-working machines *themselves* did not compare with that of European or American equipment . . . . Japanese equipment did not last as long as equipment made in other countries (possibly shorter life span was due to inferior metal being used to produce Japanese equipment). The quality control tolerances of Japanese machines were greater. Japanese equipment was suitable for producing products which did not require precise standards of accuracy but not for fine precision products.<sup>37</sup> [My italics].

In light of the realities of the demand preferences of Asian buyers, the machine tool industry's choice of concentrating production on low quality capital goods appears to have been economically rational. Nevertheless, in light of new opportunities opening up in the early 1970s to penetrate high-income markets, the upgrading of quality began to compete as an alternative strategy. Short-run and long-run considerations were at odds. For the prevailing demand preferences of low-income customers bounded the technical horizons of Taiwanese machine tool builders. The division of labour, and consequently improvements in quality, were arrested in several ways.

First, when high tolerances are required, 'machines such as grinders, honers, [and] lappers become either absolutely essential or else of very high efficiency as compared to ordinary production machinery'.<sup>38</sup> The introduction of such machinery raises average costs, however great the scale of operation. Price increases must follow to protect profit margins. Many machine tool manufacturers did not introduce specialized machinery. Thus their poor gear grinding facilities lowered the tolerances of their products.

Second, key parts of machine tools were not

hardened sufficiently because of improper heat treatment. 'Few firms had developed standard procedures or specifications, and smaller shops were not even equipped with a hardness tester'.<sup>39</sup> Precise grinding and proper heat treatment both involve large capital outlays as well as skillful attention to detail. Most factories, however, did not invest in formal training to upgrade the skills of their workers. It was reported in 1973: 'Although there are many types of high level training organizations in Taiwan, very few [machine tool] factories send their workers for training in these... organizations... [or] abroad'.<sup>40</sup> Skilled labourers such as fitters are essential for high quality output.

Third, even in the best tool shops, standardization was not achieved. This was partly due to the 'reworking of parts by hand operations' and 'the absence of assembly line procedures'.<sup>41</sup> From all available evidence, it appears that machine tool firms which built themselves up from their foundations utilized hand methods of production wherever possible to save costs. The scope for factor substitution, however, narrows severely as standardization and interchangeability become overriding.<sup>42</sup> Some hand methods unknown in machine tool shops in advanced countries today are still in evidence in the best tool shops in Taiwan.<sup>43</sup> Such methods appear to endure partly because they are vestiges of custom-made factory organization. But undoubtedly such methods also endure because they continue to save costs at the sacrifice of quality.

Fourth, quality control itself costs money and strict quality control was not practised. Separate quality control (Q/C) departments were nonexistent in many factories. Where they did exist, the chain of command linking them to top management was frequently judged to be incorrect. In some cases, the Q/C department was responsible to the production manager, with output quotas to meet, rather than to the chief executive or plant manager. The family form of business organization also appeared in a few instances to give rise to uncertain chains of command. The closely held corporation is generally attributed with flexibility and quick decision-making powers. Nevertheless, as the size of a few closely held Taiwanese corporations increased, necessitating the sharing of responsibility among several family members, it became unclear where ultimate authority rested. In one company, for example, the jurisdictions of the plant manager and his brother-in-law, the production manager, were unclear and 'no-one made the workers knuckle down'.<sup>44</sup>

Fifth, the best Taiwanese lathes were judged inferior in quality to the standard engine lathe of a leading American tool builder (with a branch in Singapore) simply because they lacked such 'finishing touches' as a professional paint job. (Other types of machinery in Taiwan were said to lack such 'finishing touches' as safety devices.)

Finally, the demand preferences of small-scale machine tool users appear to have influenced the division of labour *between* the machine tool industry and auxiliary support industries. These demand preferences had a bearing on the phenomenon of verticalization discussed earlier. The short life of Taiwan-made machine tools may be inferred from the report on the Philippine market quoted above. Rapid depreciation has been attributed to the inferior castings produced by many integrated machine tool builders. Castings are inferior due to antiquated foundry equipment and the use of low grade raw materials. The situation was not unavoidable since a first-class foundry exists in Taiwan. It has gone 'to extremes to prepare and select high-quality raw materials... and to prepare molding sand properly... to minimize blow-holes and defects'.<sup>45</sup> But machine tool establishments have not patronized it. Where casting is out of the question in the smallest machine tool shops, third-rate foundries have been patronized. Presumably lower quality castings have been judged by the industry to be more suitable cost-wise for the type of machine tools in popular demand locally and in South-east Asia (this is in spite of the offsetting diseconomies of underutilized capacity in foundries).

The problem of meeting international standards of quality appears to be widespread in Taiwan. This is not surprising, given that many industries have progressed beyond the teething stage of industrialization and are in the process of consolidation. A preoccupation with quality is evidenced by the following survey results.<sup>46</sup> In 1972, 900 firms in a wide range of industries were asked to rank the subjects they thought most important for inclusion in a university level engineering curriculum. Three hundred firms responded. The subject they ranked most important was Quality Control (Manufacturing Technology was ranked second, Engineering Design third, and Business Management fourth). The same firms were also asked to rank a total of 38 basic skills and types of knowledge they considered most important for engineering students to acquire. Of the 38 possibilities, Quality Control was ranked second (and Cost Control fourth).

These survey results indicate that without the expertise of Q/C engineers trained at government expense, many firms, not least of all machine tool builders, have been *unable* to respond to exhortations to improve their quality from the engineers who dominate the Ministry of Economic Affairs (MOEA). In the production of machine tools, moreover, to which discussion is restricted, higher quality requires much more than paying the salaries of Q/C engineers and other professionals. It requires an intricate and relatively expensive combination of additional inputs. The literature on economic development focuses on shortages of capital, for investment in equipment and skills, as impediments to the attainment of higher quality. But the attainment of higher quality at an acceptable rate of profit depends not only on interest rates but also on the price elasticity of demand to which production is oriented. We have stressed that machine tool production in Taiwan throughout most of its history has been oriented largely toward a market characterized by a high price elasticity of demand and a preference for economy at the expense of quality. Price increases in the wake of quality improvements might drive customers to even cheaper sources of supply or to the second-hand machine tool market. Consequently, we argue that machine tool builders have been hesitant to respond to the exhortations of MOEA technicians to improve their quality, given the balance of costs and revenues involved. It may have appeared unduly risky for machine tool builders to rationalize production and raise new capital to elevate standards when the ability and willingness of major customers to pay for a superior product was uncertain. The risks of sinking new capital to elevate standards in the transitional period under discussion were heightened by the uncertainty of demand for Taiwan-made machine tools from the US, Japan and Australia in times of economic normalcy. An even shorter-run consideration was also at play. In the boom time conditions characteristic of the early 1970s, firms with orders to fill were eager to produce as much as possible as quickly as possible, quality notwithstanding.

#### IV. FUTURE PROSPECTS

There is much to suggest that in the coming years, leading machine tool builders will orient their output to more sophisticated machine tool users. For if nothing else, in a growing economy and changing international environ-

ment, it is virtually impossible to stand still. The mainstay of the Taiwanese machine tool industry in its formative years was a cheap supply of labour. But during the world-wide inflation which accompanied the Vietnam war, first prices and then money wages skyrocketed in Taiwan. Wages rose on the order of 30–40% in 1973–74 alone.<sup>47</sup> The gains of skilled workers were even greater. The approach of full employment in Taiwan promises to make wage increases enduring.

Higher labour costs may be hypothesized to lead to higher investments in skills and to the substitution of machines for men, although machine tools are not an especially capital-intensive good.<sup>48</sup> Higher labour costs may also be expected to induce machine tool builders to introduce more productive equipment. For when the wages of a machine operator increase, a less productive piece of equipment is less economical to run. More capital-intensive methods of production are conducive to standardization and interchangeability of parts. The building of a more reliable machine tool will enable the industry to penetrate higher-income markets.

A rise in the wage–rental ratio in the presence of indivisibilities need not, of course, prompt factor substitutions. It may still be cheaper to use the same methods to produce a machine tool of the same quality as was previously produced. If, however, the capital–labour mix and the quality of final output remain unchanged, higher labour costs will make it a dubious strategy for Taiwanese machine tool builders to compete on the basis of price alone.

Taiwan-made machine tools are far less expensive than those of advanced countries (although the gap is narrower with respect to Japanese equipment). But the prices of most Taiwan-made machine tools are rising, in conjunction with escalating labour costs.<sup>49</sup> Further price hikes will place them in a competitive league with Chinese machine tools especially. In the opinions of many distributors in Southeast Asia, however, the quality and design of the machine tools of the PRC are superior to those of the ROC. US machine tool makers also agree that:

...the Chinese tools, though unsophisticated, are of good quality. In such markets as Mexico or India, 'they could really be formidable'...

According to the North American distributor of PRC machine tools:

We've had no problem with uniformity... The machines are well made, and the finish is absolutely superb...<sup>50</sup>

Higher-priced, Taiwan-made machine tools are also likely to meet competition from Japanese and American machine tool builders with subsidiaries abroad. There are signs of a second wave of direct foreign investment in cheap labour countries like Taiwan. The first was characterized by the production of labour-intensive manufactures for export. Now more sophisticated exports appear on the agenda. A few American and Japanese machine tool builders (and other machinery makers) have located their subsidiaries in Taiwan and Singapore, where wage rates are not only low by international standards but where labour is also 'trainable'. The quality of the machine tools built by local firms in Taiwan is undoubtedly inferior to those of expatriates.<sup>51</sup> German machine tool builders are also 'stepping up investment abroad'. German machinery builders 'are suddenly discovering that price now really matters, quality or no quality'.<sup>52</sup> But while the German machine tool industry may have to lower its prices in the coming years to stay competitive, the Taiwanese machine tool industry will have to raise its quality.

The successful penetration by Taiwanese machine tool builders into higher-income markets may depend critically on government support. So, too, may the specialized, standardized and serialized production of a wide assortment of more complicated machine tools. The necessary degree of government support for the creation of an integrated capital goods sector is of course a controversial subject.<sup>53</sup> It begins a new chapter at the point where our history of machine tool building in Taiwan ends. Suffice it to say here that the production of heavy capital equipment was never left to the initiative of the private sector. The government-owned Taiwan Machinery Manufacturing Corporation has since 1946 manufactured a diverse assortment of heavy equipment with a labour force of over 3,000. With respect to aid to the private sector, the government has singled out machinery manufacturers for special support. The government has re-oriented its development strategy in light of the approach of full employment. Instead of promotion of labour-intensive exports, recent development plans encourage the production of technology- and skill-intensive goods. One major source of government support to the machine tool sector will be an integrated steel mill, scheduled for completion in 1978. High-quality alloy steels, steel forgings, and iron for castings are essential for high-quality machine tools. Other government support to the industry, while clearly less comprehensive than in

a planned economy, includes vocational and management training, technical assistance, export promotion, and subsidized finance.<sup>54</sup> Whether such support will be sufficient for the modernization of machine tool production remains to be seen. What also remains to be seen are the full effects on the industry of the world-wide slump in capital goods production that followed the boom which in no small part accounted for the successes of machine tool firms in the early 1970s.

## V. CONCLUSIONS

The production of machine tools has long been associated with industrialization, for machine tools are the building blocks of a capital goods sector and require an intricate combination of fairly sophisticated techniques. How the rise of an indigenous machine tool industry was accomplished in Taiwan, therefore, is of some general interest. We have singled out the type of market facing the Taiwanese machine tool industry as an independent variable influencing its growth pattern. We have argued that during the industry's formative years, the material conditions of machine tool users retarded the division of labour in machine tool construction. Certain technical advances in machine tool construction could only proceed as quickly as the material conditions of machine tool users improved. It is in this sense that the division of labour is limited by the type of market. A nucleus of progressive machine tool builders in Taiwan captured the benefits of scale economies from an expansion in the size of the market in the form of exports to Southeast Asia and Hong Kong. But the multiplication of the number of consuming units did not eliminate altogether the constraint on the division of labour of the restricted purchasing power and associated preferences of individual buyers.

This suggests that the formation of common markets and free trade areas among equally backward countries may be insufficient to generate technological progress on all fronts in the manufacture of goods with production functions similar to those of machine tools. For technology to advance, clearly capital accumulation must proceed. The multiplication of markets alone is insufficient. The Taiwanese experience also suggests that insights into the problems of producing goods like machine tools may suffer if attention is focused myopically on factor constraints. Undoubtedly spatial and temporal variations in supplies of capital and

skills affect technological progress. But the nature of the market to which production is oriented also exerts an independent influence, in economies where private production is ultimately geared to profit-making.

In Taiwan, capital accumulation has been extraordinarily rapid due to reforms in agriculture and exports of labour-intensive manufactures. These economy-wide strides in productivity propelled the machine tool industry along its way. So, too, did sales of machine tools to Southeast Asia and the fortuitous world-wide boom precipitated by the Vietnam war. With hardly any government aid or foreign assistance, the machine tool industry in Taiwan came alive. Two points are particularly relevant to would-be machine tool builders in other developing countries starting production with a minimum of resources.

First, in the absence of exceedingly rapid capital accumulation, opportunities for sales to other developing countries, and fortuitous breaks, the production of general-purpose machine tools, if left to the free market, may proceed as slowly and erratically as it did in Taiwan prior to the late 1960s, when massive exports of labour-intensive manufactures accelerated.

Second, while a small nucleus of firms in Taiwan succeeded by trial and error in building general-purpose machine tools just short of international standards of quality, this cannot be described as a monumental achievement. For in the early stages it may not be unduly difficult to make substantial gains. What is

needed are a handful of enterprising and energetic entrepreneurs and an abundant supply of cheap labour to cushion the costs of inefficiency and mistakes. The decisive test is the ability to produce a wide assortment of high-precision machine tools. This has yet to be accomplished in Taiwan. To do so may not only require extensive government support – it may also require overcoming traditions and habits such as verticalization, non-standardization, and sub-optimal size firms which became entrenched in the early stages.

We have been concerned with technical progress and growth in the long run in the production of machine tools. In this context, we have questioned the conditions under which it is economically rational for private firms to produce a low-quality machine tool with an elementary division of labour. Central to our analysis has been the treatment of quality as an economic variable. The incorporation of quality as an economic variable in analyses of intermediate technologies may, in general, prove fruitful. There may be little scope for factor substitution in the production of rigidly defined products. But factor proportions more suitable to the endowments of underdeveloped countries may be economically feasible once the quality of products is free to vary. If lower quality goods can in fact be produced profitably, they may not only be relatively labour-intensive in their input requirements. As in the case of Taiwanese machine tools, they may also be capital-saving in use and hence, appropriate in the direct factor use sense as well.

#### NOTES

1. Allyn Young, 'Increasing returns and economic progress', *Economic Journal* (March 1928).

2. 'Machine-tool output is \$13 billion', *American Machinist* (15 January 1975).

3. For a discussion of factor substitution in metal-working processes, see G. K. Boon, *Economic Choice of Human and Physical Factors in Production* (Amsterdam: North Holland, 1964).

4. Edward H. Chamberlin, 'The product as an economic variable', reprinted in his book, *Towards a More General Theory of Value* (New York: Oxford University Press, 1957).

5. While visits to factories in Taiwan included lengthy interviews with various company officials, almost no firm was willing to divulge basic statistics on capital investments, profitability, etc. It is also extremely difficult to measure relationships such as output-capital ratios and labour productivity in the

production of machine tools since most firms produce a variety of machine tools and a host of ancillary inputs. Some firms also produce final products other than machine tools. Government data on these characteristics of machine tool production suffer from the same problems. Government data on machine tool output are also not entirely reliable given the sampling and inference procedures used. It is also difficult to measure accurately the percentage of machine tools exported given different definitions in trade and output series and alterations in such series. It is for these reasons that the following discussion is largely descriptive.

6. Si-Chen Kao, 'Development of machinery industry in Taiwan', *Industry of Free China* (April 1969).

7. The early difficulties of the industry are briefly discussed in Industrial Development Bureau, MOEA, 'The machinery industry in Taiwan' (1974), (mimeo).

8. The Executive Group of ICCT, *General Report 1961, Industrial and Commercial Census of Taiwan, The Republic of China, Vol. III* (December 1962).
9. *ibid.*
10. An American company called Presto, Inc. appeared to be typical. It manufactured parts for TV sets with a work force of 130.
11. Nathan Rosenberg, 'Technological change in the machine tool industry, 1840-1910', *Journal of Economic History* (December 1963).
12. The ratio of Taiwan's imports to local production of machine tools was almost 0.5 in 1974 according to *American Machinist*, *op. cit.*
13. Information on the government-owned arsenal in Kaohsiung was related to me by O.D. Lascoe, Professor of Engineering, Purdue University, and coordinator of an International Productivity Symposium sponsored by the National Science Council, Republic of China.
14. Committee on Industrial and Commercial Censuses, *The 1971 Industrial and Commercial Censuses of Taiwan and Fukien Area, Republic of China, Vol. III, Manufacturing (Taiwan Area)* (June 1973).
15. In the late 1960s, a few of the larger machine tool builders entered into technical agreements with Japanese machine tool firms. In the case of one company, in-plant assistance was provided by the staff of the American distributor of the company's lathes. Another firm received in-plant help from an engineer who was a member of the International Executives Service Corporation. But such intimate foreign assistance was lacking in most other machine tool firms even in the early 1970s.
16. Metal Industries Development Centre (MIDC), 'Introduction to metal industries in Taiwan, ROC' (July 1973), (mimeo).
17. This information was related to me by R. F. Nye, Machine Industry Consultant, Engineering Consulting Group, MOEA.
18. For the figure for Japan, see Toyoroku Ando, 'Interrelation between large and small industrial enterprises in Japan', *Industrialization and Productivity*, Bulletin No. 2 (March 1959) as quoted by Boon, *op. cit.*, p. 47.
19. George Stigler, 'The division of labour is limited by the extent of the market', reprinted in his book, *The Organization of Industry* (Homewood, Ill.: Richard D. Irwin, 1968).
20. For a discussion of technical convergence, see Edward Ames and Nathan Rosenberg, 'The progressive division and specialization of industries', *Journal of Development Studies* (July 1965).
21. These were the impressions of Mr. Orvis J. Fairbanks, Senior Industry Advisor, UNIDO. Interview, Jakarta, September 1974.
22. Chu-Yuan Cheng, *The Machine Building Industry in Communist China* (Chicago: Aldine Atherton, 1971). For information on Soviet machine tools, see David Granick, *Soviet Metal-Fabricating and Economic Growth* (Madison: University of Wisconsin Press, 1967).
23. These percentages are reported in UNIDO, *The Machine Tool Industry* (1974), E. 74 II.B.3. The report gives a general description of machine tool production.
24. David S. Landes, *The Unbound Prometheus* (London: Cambridge University Press, 1970), pp. 105-108. For a general discussion of standardization in the machinery sector, see John E. Wilson, 'The problems and significance of industrial standardization in metalworking industries in developing countries', in UNIDO, *Development of Metalworking Industries in Developing Countries* (1969). This publication contains many useful reports on machine tool building presented at a UN Interregional Symposium, Moscow, 7 September-6 October 1966 (E.69.II.B.2).
25. These regulations were related to me by Mr. Philip Wang, Industrial Development and Investment Centre, MOEA. The regulations also appear in publications by the same organization.
26. M.C. Liu, 'A case report on promotion of national industrial standards by introduction of foreign investment: the change of the sewing machine industry on the island' (19 August 1968), (mimeo, translation), and information obtained in visits to three sub-contractors of sewing machine manufacturers.
27. ECLA, 'The manufacture of machine tools in Argentina', and ECLA, 'The manufacture of machine tools in Brazil', in UNIDO, *Development of Metal working Industries in Developing Countries*. See also UNIDO, *Machine Tools in Latin America* (1974) E.73.II.B.II.
28. Commission of ICCT, *General Report on Third [1966] Industrial and Commercial Census of Taiwan, ROC, Vol. III, Manufacturing* (June 1968).
29. Industrial Development Bureau, 'The machinery industry in Taiwan
30. *ibid.*
31. MIDC, 'A brief survey of machine tool firms' (June 1973), (mimeo).
32. An easing in interest rates is indicated in Central Bank of China, *Taiwan Financial Statistics Monthly*, various issues. See also Mo-Huan Hsing, *Taiwan: Industrialization and Trade Policies* (London: Oxford University Press, 1971), Table A23.

33. Industrial Development Bureau, 'The machinery industry in Taiwan'.
34. As indicated in Note 5, it is difficult to compute accurately machine tool exports as a percentage of machine tool production given differences in definitions in output and trade figures. The range of 25-40% stems from information from the *American Machinist*, op. cit., and the Industrial Development Bureau, *ibid*. It is of some interest that machinery exports in general have risen dramatically. They increased 18-fold in 8 years, from 1967-74. (*China Post*, 1 April 1975).
35. The types of buyers of Taiwan-made machine tools in the US was suggested by an American distributor of Taiwan-made lathes.
36. US Embassy, Philippines, Commercial Attache, 'Metalworking machine tools and metal finishing equipment', Desk Study (1973).
37. Hakudo, Inc., 'A study of metal-processing equipment in Thailand' (March 1966), (mimeo).
38. A. J. Rowe and H. Markowitz, 'An analysis of machine tool substitution possibilities', Rand Corporation RM-1512 (30 June 1955).
39. MIDC, 'Introduction to metal industries in Taiwan, ROC'.
40. Industrial Development Bureau, 'The machinery industry in Taiwan'.
41. These were the opinions of American and Taiwanese engineers who accompanied me on my visits to various factories.
42. See, for example, Frances Stewart, 'Choice of technique in developing countries', *Journal of Development Studies* (October 1972).
43. Some hand methods, e.g. the hand polishing of beds, when undertaken by skilled workers, may result in a very high quality machine tool. But elevated standards of craftsmanship did not characterize the hand methods under discussion.
44. These types of remarks were made repeatedly by engineers from the MOEA.
45. Arthur D. Little, Inc., 'The outlook of the non-electrical machinery and equipment industry in Taiwan', Reprinted by the Industrial Development and Investment Centre, MOEA (1974).
46. Jack Wu, *Analytical Model of Curriculum Development and Evaluation for Manufacturing Engineering Educational Programmes* (May 1973), Purdue University, Ph.D. Engineering, Industrial.
47. According to the MOEA, wages for workers in manufacturing increased by 53.2% between June 1973-June 1974. *Industry of Free China* (September 1974).
48. In the US in 1965, using a base of 100 for all industry, metal-cutting machine tools had a value added per employee of 104.9 and metal-forming machine tools had a value added per employee of 104.4. Given a number of assumptions, the higher the value added per employee, the greater the degree of capital intensity (both material and human). Thus, machine tools in the US fall in the middle and not in either extreme of the capital/labour spectrum. (Hal B. Lary, *Imports of Manufactures from Less Developed Countries* (New York: National Bureau of Economic Research, 1968), Table C-1.) Machine tool production in Taiwan is almost sure to be more labour-intensive than machine tool production in the US, although much depends on the type of machine tool produced and the size of the firm. In Latin America, capital-intensity and firm size were positively correlated in machine tool production. UNIDO, *Machine Tools in Latin America*, p. 67.
49. It was estimated by the MIDC that the price of a particular lathe of a leading machine tool builder increased by 43% between January and October 1973 ('A brief survey of machine tool firms'). Figures on the number and total sales of machine tools published by the MOEA, *Taiwan Industrial Production Statistics Monthly*, also indicate that the value per set of lathes and drilling machines has risen considerably.
50. 'China scores with its machine tools', *Business Week* (16 June 1975).
51. It is interesting to read the catalogue for the 'Regal' Lathe of LeBlond, a leading US machine tool firm with a branch in Singapore. It provides an indication of the marketing strategy of the company: 'There are sound reasons for the universal acceptance of LeBlond Regals by industry... Small shops can justify a Regal instead of buying someone else's problems in a used machine. Maintenance departments and toolrooms like the Regal's nimble mastery over many jobs. Large plants equip entire bays with Regals to achieve profitable production and flexibility... LeBlond Regals are accurately built to the close precision tolerances usually found in much more expensive lathes'.
52. 'Letter from Swabia: machine builders retool their thinking', *Business Week* (9 June 1975).
53. See, for example, Krishna D. N. Singh, 'Import of capital goods' and 'Comment' by Nak Kwan Kim in Kiyoshi Kojima and Miguel S. Wionczek (eds.), *Technology Transfer in Pacific Economic Development*, Centre Paper No. 25 (Tokyo: The Japan Economic Research Centre, January 1975). Also of interest is K. N. Raj, 'Role of the "machine-tools sector" in economic growth: a comment on Indian and Chinese experience' in C. H. Feinstein (ed.), *Socialism, Capitalism and Economic Growth: Essays Presented to Maurice Dobb* (London: Cambridge University Press, 1967).



54. Early in 1975, the government appropriated US \$5 million to finance imports by the machinery industry of the latest technical know-how. Other soft loans to machinery makers have also been approved. See *The Economic News* (2 May 1975); and *Taiwan Industrial Panorama* (1 June 1975), Publication of the Industrial Development and Investment Corporation, MOEA. Taiwan-made machinery exhibitions are scheduled for 12 overseas locations (Hong Kong, Japan, Brazil, US, Indonesia, Ivory Coast, South Africa, Colombia, Guatemala, Saudi Arabia, Jordan and Argentina). *Free China Weekly* (21 September 1975). Direct assistance to machine tool builders is indicated by the following: '...trade sources said that the quality of machines now being exported has been upgraded, and the export markets expanded to the Middle East, Africa and Latin America. Meanwhile,

the government is thinking of limiting the import of machine tools to those of the US and Europe [Japan is conspicuously absent] in an attempt to help upgrade the technical level of [the] local machinery industry'. *Free China Weekly* (15 June 1975). It should be noted that beginning in the 1960s, the Taiwan Government prohibited the importation of used machinery. Whether or not machine tool builders benefited from such protection is questionable. It is rumoured that used machinery is in fact imported into Taiwan as scrap. The price of second-hand machine tools in the American market has also been high (sometimes equalling or exceeding the original price). Thus, second-hand American machine tools are unlikely to have been competitive price-wise with Taiwan-made machine tools even in the absence of import restrictions.